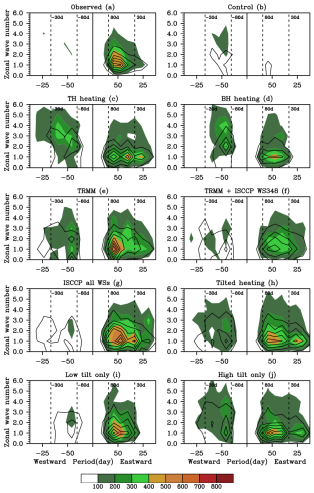
Madden–Julian Oscillation Heating: to Tilt or Not to Tilt

Research Highlight

It is hypothesized that specific cloud populations at different stages are essential to the initiation and maintenance of the Madden-Julian Oscillation (MJO). In particular, the occurrence of shallow convection that then transitions to mid-level convection before the active phase of the MJO is thought to provide lower-level heating that then promotes large-scale moisture convergence necessary for the MJO to form. This research presents results from model runs of a modified version of the Community Atmospheric Model version 4 (CAM4) to show the relative importance of low-level heating in the evolution of the MJO.

The control version of CAM4 does not produce a clear MJO (Figure 1b), so we modified the model to accept additional heating at each time step while maintaining fully interactive physics. We used idealized and realistic heating profiles with a variety of tilts. It appears that low-level heating ahead of the MJO convective center is critical for the initial strengthening and later maintenance of the MJO (Figures 1d-i). However, tilted heating is not necessary to simulate a realistic MJO (e.g., Figure 1d). Excess upper-level heating (whether tilted or not) degrades the MJO signal (Figures 1c, h, and j). These results suggest CAM4 likely produces sufficient upper-level heating but a deficient lower-level heating to initiate and maintain an MJO.

Eastward propagating tilted heating, associated with a cloud population that evolves from shallow to deep, forces the most realistic MJO signal in outgoing longwave radiation (OLR) and winds in CAM4. Eastward propagating low-level heating with no tilt and weak low-level heating over the active MJO region that does not propagate eastward also force a reasonable MJO response. Thus, it appears that the MJO is most sensitive to the existence of low-level heating ahead of the MJO center and not necessarily its vertical tilt or propagation.



In this figure, November through April wavenumber frequency spectrum of OLR (colors) and 850 hPa winds (lines) from observations and nine simulated cases are shown.

Reference(s)

Lappen C and C Schumacher. 2014. "The role of tilted heating in the evolution of the MJO." Journal of Geophysical Research – Atmospheres, , 10.1002/2013JD020638. ACCEPTED.

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Cloud Life Cycle